J. Dairy Sci. 98:1–8
http://dx.doi.org/10.3168/jds.2014-8436
© American Dairy Science Association®, 2015.

Hot topic: Innovative lactation-stage-dependent prediction of methane emissions from milk mid-infrared spectra

A. Vanlierde,*[1] M.-L. Vanrobays,†[1] F. Dehareng,* E. Froidmont,‡ H. Soyeurt,† S. McParland,§ E. Lewis,§ M. H. Deighton,# F. Grandl,‖ M. Kreuzer,‖ B. Gredler,¶ P. Dardenne,* and N. Gengler†[2]
*Walloon Agricultural Research Centre, Valorization of Agricultural Products Department, 5030 Gembloux, Belgium
†Agriculture, Bio-engineering and Chemistry Department, Gembloux Agro-Bio Tech, University of Liège, 5030 Gembloux, Belgium
‡Walloon Agricultural Research Centre, Production and Sectors Department, 5030 Gembloux, Belgium
§Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland
#Agriculture Research Division, Department of Economic Development, Jobs, Transport and Resources, Ellinbank Centre, Ellinbank, 3821 Victoria, Australia
‖ETH Zürich, Institute of Agricultural Sciences, 8092 Zürich, Switzerland
¶Qualitas AG, 6300 Zug, Switzerland

ABSTRACT

The main goal of this study was to develop, apply, and validate a new method to predict an indicator for CH_4 eructed by dairy cows using milk mid-infrared (MIR) spectra. A novel feature of this model was the consideration of lactation stage to reflect changes in the metabolic status of the cow. A total of 446 daily CH_4 measurements were obtained using the SF_6 method on 142 Jersey, Holstein, and Holstein-Jersey cows. The corresponding milk samples were collected during these CH_4 measurements and were analyzed using MIR spectroscopy. A first derivative was applied to the milk MIR spectra. To validate the novel calibration equation incorporating days in milk (DIM), 2 calibration processes were developed: the first was based only on CH_4 measurements and milk MIR spectra (independent of lactation stage; ILS); the second included milk MIR spectra and DIM information (dependent on lactation stage; DLS) by using linear and quadratic modified Legendre polynomials. The coefficients of determination of ILS and DLS equations were 0.77 and 0.75, respectively, with standard error of calibration of 63 g/d of CH_4 for both calibration equations. These equations were applied to 1,674,763 milk MIR spectra from Holstein cows in the first 3 parities and between 5 and 365 DIM. The average CH_4 indicators were 428, 444, and 448 g/d by ILS and 444, 467, and 471 g/d by DLS for cows in first, second, and third lactation, respectively. Behavior of the DLS indicator throughout the lactations was in agreement with the literature with values increasing between 0 and 100 DIM and decreasing thereafter. Conversely, the ILS indicator of CH_4 emission decreased at the beginning of the lactation and increased until the end of the lactation, which differs from the literature. Therefore, the DLS indicator seems to better reflect biological processes that drive CH_4 emissions than the ILS indicator. The ILS and DLS equations were applied to an independent data set, which included 59 respiration chamber measurements of CH_4 obtained from animals of a different breed across a different production system. Results indicated that the DLS equation was much more robust than the ILS equation allowing development of indicators of CH_4 emissions by dairy cows. Integration of DIM information into the prediction equation was found to be a good strategy to obtain biologically meaningful CH_4 values from lactating cows by accounting for biological changes that occur throughout the lactation.
Key words: dairy cattle, mid-infrared, methane, lactation stage, milk

Hot Topic

Feed costs are the largest expense in dairy production and limit the profitability of dairy farms (Vallimont et al., 2011). Methane emissions, besides contributing to the carbon footprint of dairy products, represent a loss of use of energy intake (Johnson and Johnson, 1995). Therefore, interest is growing in mitigating CH_4 emissions, thereby reducing environmental footprint but also potentially improving feed efficiency and reducing related feed costs. Most of the CH_4 emitted by cattle is eructed. However, the measurement of eructed CH_4 emissions is difficult and expensive. To mitigate these emissions, it is important to have a cheap, fast, and robust method to measure the CH_4 emissions of individual cows on a large scale. Traits that can be easily recorded and that are correlated with CH_4 emissions are therefore of interest. De novo synthesis of milk FA in the mammary gland is dependent on the products of

Received June 3, 2014.
Accepted March 31, 2015.
[1]These authors contributed equally to this work.
[2]Corresponding author: nicolas.gengler@ulg.ac.be

ruminal fermentation (Chilliard et al., 2000), as is the production of eructed CH_4 (Chilliard et al., 2009; Dijkstra et al., 2011). Hence, changes in the FA profile of milk fat may be relevant. Because mid-infrared (**MIR**) spectrometry is known to be useful in predicting milk FA contents (Soyeurt et al., 2011), Dehareng et al. (2012) developed prediction equations to obtain individual CH_4 emissions of dairy cows directly from milk MIR spectra. However, results obtained using those equations did not fit with what was expected from the literature, showing the lowest emissions in early lactation and an increase thereafter. A hypothesis could be that milk FA profile, and therefore the relationship between CH_4 and MIR spectra, is strongly influenced by the evolution of body-tissue mobilization during lactation, leading to suboptimal predictions. Consequently, MIR prediction equations that incorporate stage of lactation may better take into account the metabolic changes that occur throughout lactation. The objective of this study was to develop, apply, and test on MIR data, a novel and readily adoptable method that includes lactation stage as a proxy for metabolic status in the CH_4 prediction equation based on milk MIR spectra. The ability of the novel method to predict a CH_4 indicator was tested on a completely unrelated external data set.

Development of Mid-Infrared-Based CH_4 Indicators

Methane Reference Measurements. Measurements of CH_4 emissions from dairy cows were obtained from the Teagasc Animal and Grassland Research and Innovation Center (Moorepark, Co. Cork, Ireland), the Walloon Agricultural Research Centre (Gembloux, Belgium), and from one commercial herd in Belgium. A total of 446 individual daily CH_4 measurements were recorded: 270 Irish records from 117 individual Holstein, Jersey, and Holstein-Jersey crossbred cows, including 49 first-, 30 second-, and 38 third- or later-parity animals; and 176 Walloon records from 25 Holstein cows including 10 first-, 6 second-, and 9 third- or later-parity animals. Measurements were conducted at different lactation stages (Table 1). This data set of CH_4 values was characterized by a minimum of 180 g/d, a maximum of 942 g/d, a mean of 416 g/d, and a standard deviation of 128 g/d. To achieve the largest possible variability required for robust calibration equations, cows were fed with very different diets: grass or high silage diets (maize vs. grass silages), with or without linseed supplementation, and synchronized or not in terms of fermentable energy and nitrogen supplies in the rumen. Daily CH_4 emissions of individual cows were determined using the sulfur hexafluoride (SF_6) tracer gas technique with a gas collection period of 24 h. Details about the methodology used to collect the breath samples of emitted gases and to measure the SF_6 and the CH_4 content were described by Dehareng et al. (2012). By using CH_4 emission data collected from different countries, environments, and feeding strategies, an increase in the variability of CH_4 emission was expected, ensuring improved robustness of the equation developed to predict CH_4 emissions.

Spectral Reference Data. On each day of the CH_4 measurements, a 40-mL aliquot of milk was collected from each cow at both the morning and evening milking. Sodium azide (0.32 g/L) was added to each sample before storage at 4°C and MIR analysis was subsequently undertaken using a MilkoScan FT6000 spectrometer (Foss, Hillerød, Denmark). Two spectrometers were used for this study, one located at the Teagasc Animal and Grassland Research and Innovation Center (Co. Cork, Ireland) and one at the milk laboratory Comité du Lait (Battice, Belgium). Two spectra were available per day and per CH_4 measurement. To obtain 1 spectrum per CH_4 record, the 2 spectra were averaged proportionally to the milk yield at each milking.

Development of CH_4 Indicator Equations. To determine the effect of inclusion of DIM information as a predictor variable, 2 prediction equations were developed using independent calibration processes; CH_4 was the dependent variable for both equations. The first prediction equation was independent of lactation stage (**ILS**) and included milk MIR spectra as the sole pre-

Table 1. Distribution of the number of records in the calibration data set, by parity and stage of lactation of cows, and country from where records were obtained, used to develop methane emissions indicators

	Parity					
	First		Second		Third or greater	
Classes of DIM	Ireland	Belgium	Ireland	Belgium	Ireland	Belgium
1 to 50 DIM	1	7	1	0	4	0
51 to 100 DIM	19	8	21	16	31	0
101 to 150 DIM	31	13	19	10	27	15
151 to 200 DIM	46	19	18	6	12	3
>200 DIM	19	33	13	6	8	40

Download English Version:

https://daneshyari.com/en/article/10974264

Download Persian Version:

https://daneshyari.com/article/10974264

Daneshyari.com